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GROUND STRESSES AT LA MINE BOUSQUET, QUEBEC

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by

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ABSTRACT

Overcoring strain recovery measurements were conducted at La Mine Bousquet in Western Quebec at a depth of 190 m below surface.

Ground stress determinations indicated a vertical stress gradient, σ_V, of 0.0326 MPa/m, and average horizontal stress gradient, $^{\sigma}$Ha, of 0.0716 MPa/m, resulting in a stress ratio, $^{\sigma}$Ha/$^{\sigma}$V, of 2.2. A horizontal N-S stress of 1.2 times the horizontal E-W stress was observed. The maximum pre-mining stress is horizontal in a northeast direction, acting perpendicular to the ore zones and the main structural trend.

Because of structural geological evidence, and the significant variation in compressive strength of various rock types, caution is recommended when extrapolating the ground stress values to a regional mine scale.

Key Words: La Mine Bousquet; Strain recovery measurements; Pre-mining stress.

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CONTRAINTES EXERCÉES DANS LE TERRAIN À LA MINE BOUSQUET, QUÉBEC

par

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RÉSUMÉ

On a mesuré la déformation produite par le surcarottage à la Mine Bousquet dans l'Ouest du Québec, à une profondeur de 190 m sous la surface.

La détermination des contraintes exercées dans le terrain a révélé un gradient de contrainte verticale, σ_V, de 0,0326 MPa/m, et un gradient moyen de contrainte horizontale, σ_{Ha}, de 0,0716 MPa/m, ce qui donne un rapport de contrainte, σ_{Ha}/σ_V, de 2,2. On a pu observer une contrainte horizontale N-S, 1,2 fois plus importante que la contrainte horizontale E-O. La contrainte maximale exercée dans le terrain, préalablement aux travaux d'extraction minière est horizontale, en direction nord-est, et est perpendiculaire aux zones de minerai et à la direction principale de l'ouvrage.

En raison de l'évidence de la structure géologique, et de la variation importante de la résistance à la pression des différents types de roches, on recommande d'être prudent lors de l'application des valeurs de la contrainte exercée dans le terrain, à l'échelle d'une exploitation minière régionale.

Mots-clé : La Mine Bousquet; Mesures de la déformation ; Contraintes exercées dans le terrain préalablement aux travaux d'extraction minière;

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INTRODUCTION

Lac Minerals Ltd. requested Elliot Lake Laboratory, CANMET, to conduct ground stress measurements at La Mine Bousquet, Quebec.

A stress measurement site was selected in the vicinity of a proposed shaft location to determine the pre-mining ground stresses. Two overcoring strain recovery measurements using CSIR triaxial strain cells were carried out.

The stress data will be used for the application of numerical modelling and the shaft design at Bousquet 2 Mine.

GEOLOGICAL SETTING

La Mine Bousquet is situated about 50 km east of Rouyn, Quebec, close to the town of Cadillac. The location of the mine and the general geology of the Abitibi greenstone belt are shown in Figure 1.

Gold-bearing zones occur within a fine-medium grained volcanoclastic sequence and are associated with felsic-mafic tuffs. Five steeply dipping ore zones exist, up to 30 m wide, which strike over 600 m with the main ore zones extending over 600 m in depth.

Poor ground conditions within the ore zones and hanging wall/footwall are mainly related to the weak, highly sheared tuff and sericitic schist zone with various degrees of schistosity (2).

At present the deepest working level is about 230 m below surface.

STRESS MEASUREMENT SITE

The stress measurement site was located at a depth of 190 m below surface, on the 3 level, as shown in Figure 2. Horizontal test holes were drilled perpendicular to the main structural trend and schistosity. Steeply

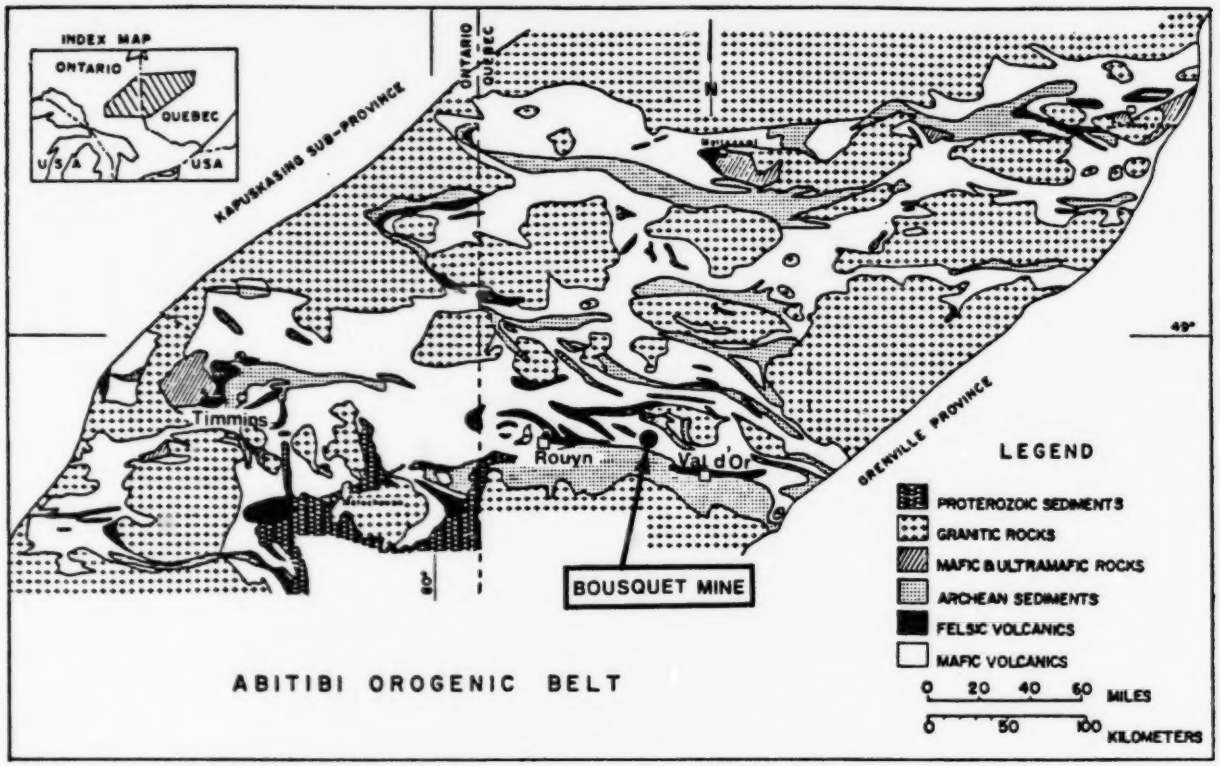
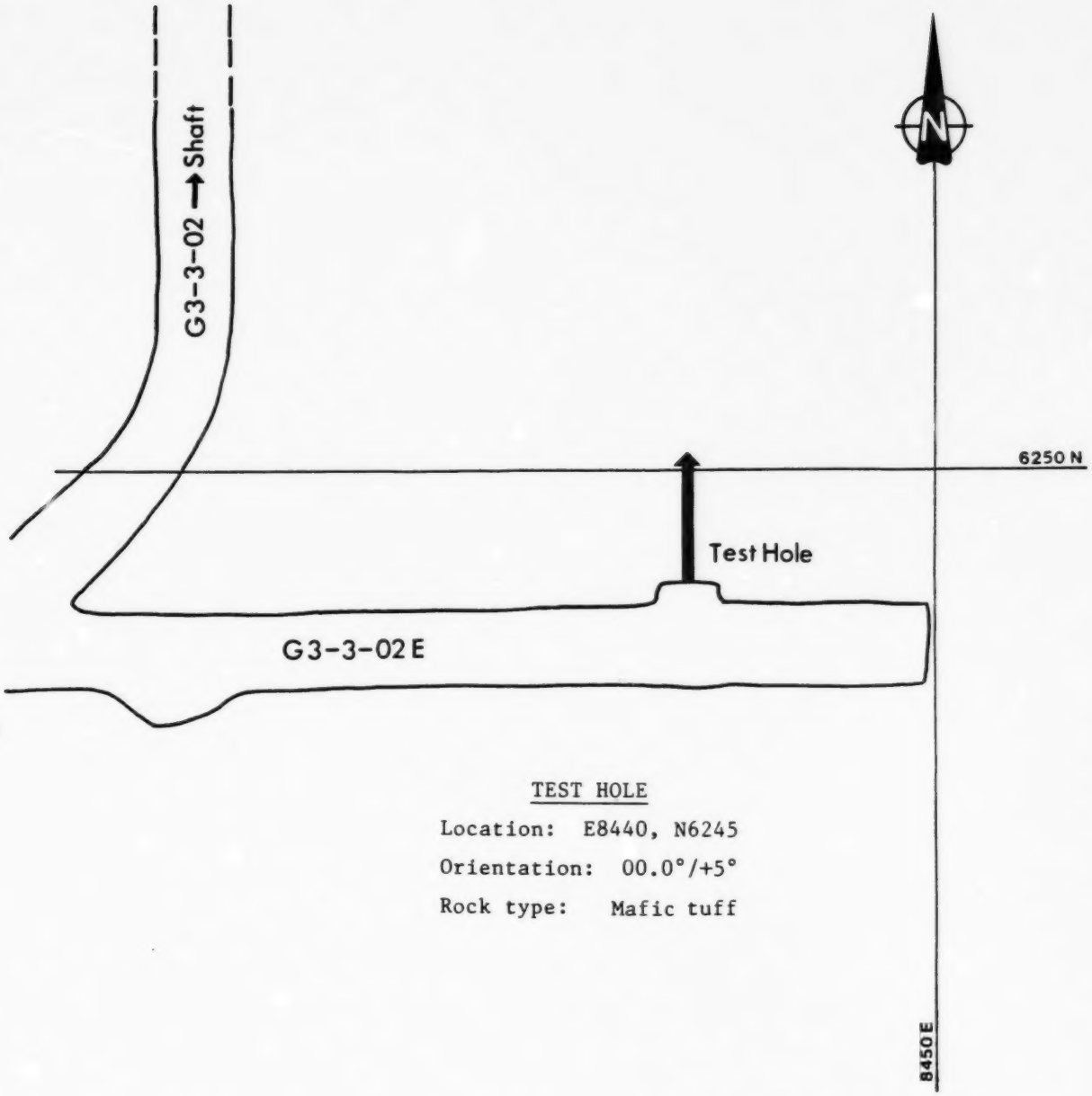


Fig. 1 - Regional geology and the location of La Mine Bousquet (1).



TEST HOLE

Location: E8440, N6245

Orientation: 00.0°/+5°

Rock type: Mafic tuff

Fig. 2 - Stress determination site and test hole location. (Scale 1:250).

dipping joints and some sub-horizontal fractures were intersected which resulted in continuous core breakage. The first test hole had to be abandoned at a depth of 9.0 m. Tests were attempted in the second hole, drilled from the same set-up. Overcoring measurements were taken in a fine-medium grained banded mafic tuff at locations 4.0 and 4.6 m from the excavation boundary.

Obtaining a competent test location to install the strain cell in highly fractured rock was difficult, hindering the field work.

FIELD STRESS DETERMINATIONS

The elastic strain recoveries from triaxial strain cell measurements are given in Table 1. The average strain invariance (sum of the strains in two orthogonal directions) for both tests amounted to about 24 microstrains. For the stress tensor calculations, an elastic modulus of 47.0 GPa and Poisson's ratio of 0.29 were used. These values were obtained from rock property tests conducted on BQ-size cores at the Bousquet Mine east (3). The values used for the elastic constants appeared to be appropriate for the rock type encountered at the stress determination site. However, additional tests are required to obtain representative data.

For the stress determinations, the data were processed by a computer program which calculates the stress components and principal stresses, and provides relevant statistical information (4). The tensor of best fit was calculated according to a least squares method. Table 2 provides the results of stress determinations. The stress components in E-W, N-S and vertical directions, and the direction of principal stresses, are related to the Mine coordinate system. The orientation of the principal compressive stresses is illustrated in Figure 3.

The results from stress determinations indicate some variations in stress magnitudes with a difference in mean stress of about 35%. The

Table 1 - Strain recovery from triaxial strain cell measurements.

Location	Test No.	Test Depth (m)	Gauge No: 1	2	3	Elastic Strain Recovery (10^{-6}) 4	5	6	7	8	9	10	11	12
3 Level G3-3-02E	B-T1	4.00	80	210	160	45	320	65	260	500	320	280	60	70
	B-T2	4.60	40	170	265	150	660	310	235	525	465	440	200	235

Table 2 - Stress components and principal stresses from field stress determinations.

Location	Test No.	Stress components (MPa) (Standard errors in brackets) σ_{EW}	σ_{NS}	σ_V	τ_{EN}	τ_{NV}	τ_{VE}	STDV	Principal Compressive Stresses (MPa) Magnitude/Orientation* σ_1	σ_2	σ_3
3 Level G3-3-02E	B-T1	9.20 (1.02)	11.85 (1.67)	5.06 (1.02)	3.42 (0.72)	-1.11 (0.72)	-0.23 (0.59)	0.47	14.25 035/05	7.15 127/20	4.70 291/69
	B-T2	15.80 (0.38)	17.50 (0.63)	7.40 (0.38)	2.30 (0.27)	0.73 (0.27)	-1.16 (0.22)	0.18	19.10 034/03	14.40 304/10	7.17 139/79

* Bearing and dip in degrees in the Mine Coordinate system (Grid North = True North).

Average standard error for stress components, 20% (Test B-T1), and 5% (B-T2).

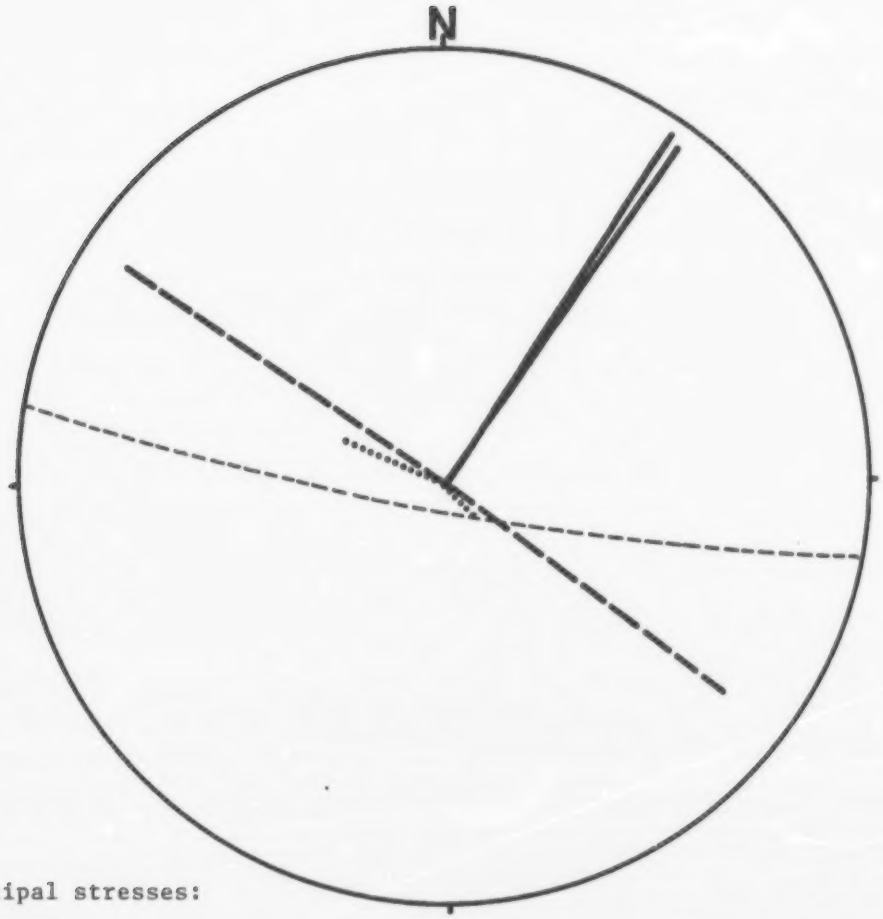


Fig. 3 - Orientation of the principal compressive stresses from Grid North (= True North) in an equal area net, lower hemisphere projection.

direction of principal stresses, however, is consistent in both tests. This reflects a rather variable stress field which is probably related to fractures and high schistosity occurring between two test locations. Since a variable stress field is apparent, the best estimate of in situ stress can be obtained when the stress values from both tests are combined. The averaged stress data resulted in the following values:

Horizontal, σ_{N-S} : 14.7 MPa

Horizontal, σ_{E-W} : 12.5 MPa

Vertical, σ_V : 6.2 MPa

Average horizontal, σ_{Ha} : 13.6 MPa

Ratio σ_{Ha}/σ_V : 2.2

Ratio $\sigma_{N-S}/\sigma_{E-W}$: 1.2

Major principal stress, σ_1 : 16.7 MPa, NE-Horizontal

Intermediate principal stress, σ_2 : 10.8 MPa, NW/SE-Horizontal

Minor principal stress, σ_3 : 6.0 MPa, NW/SE-Vertical

Mean stress, $(\sigma_1 + \sigma_2 + \sigma_3)/3$: 11.2 MPa

With regard to the orientation of ore zones (~N 100°E/85°), the major principal compressive stress is perpendicular while the intermediate principal compressive stress parallels the ore zones.

For the application of numerical modelling techniques it is required to input the pre-mining vertical stress, as well as the horizontal stresses perpendicular and parallel to the orebody. From these stress determinations the most suitable input stresses are:

σ vertical = 0.0326 MN/m^3 x depth (m) in MPa

Perpendicular σ horizontal = 2.7 x vertical stress

Parallel σ horizontal = 1.8 x vertical stress.

Structural geological evidence and significant variation in the compressive strength of the rock types indicate that some distortion in the

stress field can be expected at the mine site. It is, therefore, recommended that caution be exercised when extrapolating the ground stress values to a regional scale of the mine.

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